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PhET simulation software-based learning to improve science process skills

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Abstract. The purpose of this study is to find out the results of the application of media PhET Simulation in physics learning in matter of temperature and heat. The research design used was a randomized design control group pre-test post-test. The study population was all 11th grade students of SMA Y Serang which numbered five classes. The research sample consisted of one experimental class and one control class. The results showed that the application of physics learning using media PhET simulation on temperature and heat material produced a 37% higher N-gain value than the control class using direct learning. It can be concluded that PhET simulation software-based learning is interactive learning in physics learning and can improve students' science process skills.

1. Introduction

The progress of information and communication technology has changed the human lifestyle, both in working, socializing, playing and learning. Entering the 21st century, technological advances have entered various joints of life, including in the field of education [1]. Educators and students are required to have teaching and learning skills in the 21st century. A number of challenges and opportunities must be faced by educators and students in order to survive in the century of knowledge in this information age [2].

21st century education aims to realize the ideals of the nation, namely the people of the Indonesian nation that are prosperous and happy with an equal position with other nations in the global world, through the formation of a society consisting of qualified human resources namely independent, willing and capable of creating the ideals of the nation [3]. Meanwhile, there are challenges to facing global competition. The competitiveness is largely determined by quality education. The quality in question is not only able to meet national standards, but also to meet international standards so that Indonesia's human resources are able to compete with other countries.

To develop 21st century learning, the teacher must begin a step of change, namely changing the traditional learning pattern centered on the teacher into a student-centered learning pattern [4]. Traditional learning patterns can be understood as a pattern of learning where the teacher gives a lot of lectures while students listen more, record and memorize. One other important thing is that the teacher will be an example of a learner. The teacher must follow the latest developments in science so that in the whole learning process the teacher and students will learn together but the teacher has the task of directing and managing the class.



The 21st century learning has its own challenges, namely building knowledgeable communities that have ICT (Information and Communication Technologies) expertise and science process skills. Characteristics of 21st century society can be built through the integration of ICT in the learning process [5]. In the context of education, the real role of ICT is as a tool to enable the occurrence of effective and efficient learning processes. So, ICT is a means to achieve the learning goals planned by the teacher.

The ICT-based learning activities include listening to material from the radio, viewing material shows via TV, making presentations using laptops / computers and LCDs, printing report results with printers, making observational videos or certain objects with hand phone camera, search for learning resources through the internet and intranet, communicate via telephone or social media, send e-mails and create a community through social networking facilities [6].

One of the 21st century learning integrated with ICT that can be utilized through PhET software simulation (Physics Education Technology). PhET is a simulation developed by the University of Colorado which contains a simulation of physics, biology and chemistry learning for the benefit of classroom learning or individual learning. PhET simulation emphasizes the relationship between real-life phenomena and underlying science, supports learning with interactive and constructivist approaches, provides feedback, and provides a creative workplace [7].

PhET simulation media, when reviewed based on the Dale's Cone of Experience, this media is included in the most concrete level, where 90% of students will be actively involved in learning activities to observe, conduct experiments, and conclude the data obtained. PhET's media simulation of Energy Forms and Changes presents a visualization of the forms of energy and energy changes that exist in everyday life. Through a PhET simulation system that can be created by students so they can conduct experiments and observations to understand the form of energy and the process of changing the form of energy to other forms of energy [8].

The use of PhET simulation media gets maximum results if supported by careful preparation and knowing and implementing the stages of use of the media. The following are the stages of using PhET simulation media that have been described in the PhET's Reflection Rubric, namely: (1) Classroom Preparation, (2) Activity Sheet, (3) Pre-Post Assessment (Optional), (4) Topic Introduction and Motivation, (5) Sim Play Time, (6) During Sim Activity, and (7) Reflections [9].

Based on the explanation above, it can be said that PhET simulation media are instrumental factors or factors originating from outside whose existence and use are designed according to the expected learning outcomes [10]. In this case, the learning outcomes to be achieved are students' science process skills.

Science process skills are all skills used to discover and develop science with the scientific method [11]. Science process skills are the ability of students to apply scientific methods in understanding, developing and discovering science [12]. Science process skills are very important for every student as a provision to use scientific methods in developing science and are expected to gain new knowledge or develop knowledge that they already have.

Science process skills are a complex set of abilities commonly used by scientists in conducting scientific investigations into a series of learning processes [13]. Science process skills are the ability of students to apply scientific methods in understanding, developing and discovering science [14]. Science process skills are very important for every student as a provision to use scientific methods in developing science and are expected to gain new knowledge or develop knowledge that they already have [15].

2. Methods

The method used in this study is a quasi-experimental method with a randomized pre-test and post-test control group design study design. This research was conducted by giving treatment to the experimental group and giving the control group as a comparison. This design consisted of two groups, each of which was given a pre-test and post-test which was then treated with the method of learning based on PhET simulation software or not. The population in this study were 11th grade

students of mathematics and natural sciences at Serang 6 Public High School, Banten Province in the academic year 2018/2019 with a total of 5 classes with each class consisting of about 25 students. The sample from this study was selected using the random sampling class so that two sample classes were selected. Understanding students' concepts is measured using multiple choice test instruments as many as 10 questions about the concept of temperature and heat given before the pre-test and after treatment in learning post-test. Before the instrument was used in the study, the test instrument was tested for validity beforehand by an expert consisting of one FKIP Physics lecturer at the Sultan Ageng Tirtayasa University and two physics subject teachers at 6 Serang State High School in Banten Province.

The stages of observation in the use of PhET simulation media on learning with temperature and heat material were carried out in several stages: (1) preparing the class, educators preparing computers for simulation and placing students in small groups for collaborative learning, (2) activity sheets, educators distribute activity sheets that contain instructions and procedures for using PhET simulation media and students use to record observations, (3) introduction and motivation, before using PhET simulation media students will be given preliminary material about temperature and heat, and related discussions (4) exploration of simulation, students are given 3-10 minutes to explore PhET simulations by observing changes in temperature and heat that occur in the simulation, (5) activities during the simulation, students try to explore simulations and observe the visualization of the form e energy and energy change events, and record the findings to answer the problems in the activity sheet, (6) reflection, in each group present the results of their observations and educators provide explanations and follow-up of the overall learning activities of students and (7) provide an assessment before learning (pre-test) and or assessment conducted after learning (post-test).

3. Result and Discussion

The assessment carried out in this study is an observation to find out students' science process skills obtained from students' answers on the pre-test and post-test question sheets. The test questions contain aspects of students' science process skills, including: observation, communication, classification, measurement, inference, prediction. The results of data analysis pre-test, post-test, and normal gain scores obtained by the experimental class and control class students are presented in Figure 1.

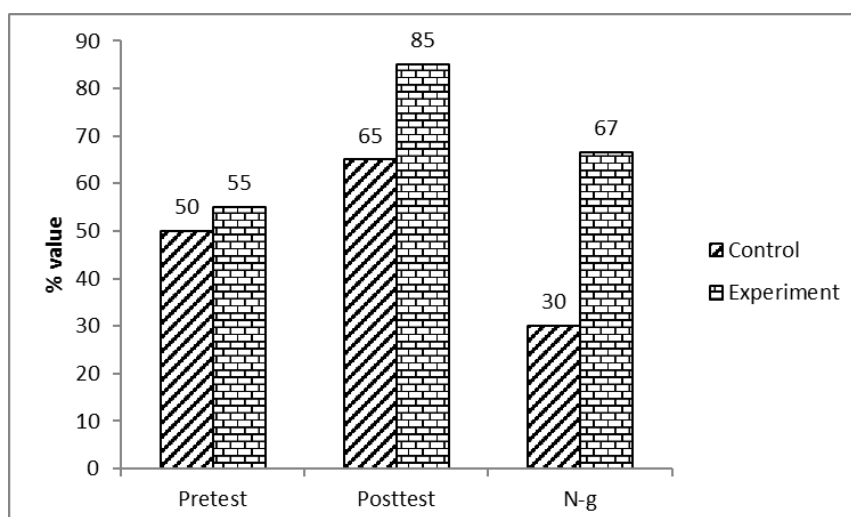


Figure 1. Comparison of graphs of the average scores of pre-test post-test and gain normalized science process skills of students

From Figure 1, it can be seen that the percentage of normalized gain value $\langle N-g \rangle$ science process skills of students in the experimental class is 67, while in the control class 30. So, it is concluded that

the skills of science process students in experimental class with PhET simulation software-based learning higher than the control class.

In detail, the comparison of normalized gain values for each aspect of students in the temperature and heat material obtained by students in the experimental class and the control class is presented in Figure 2.

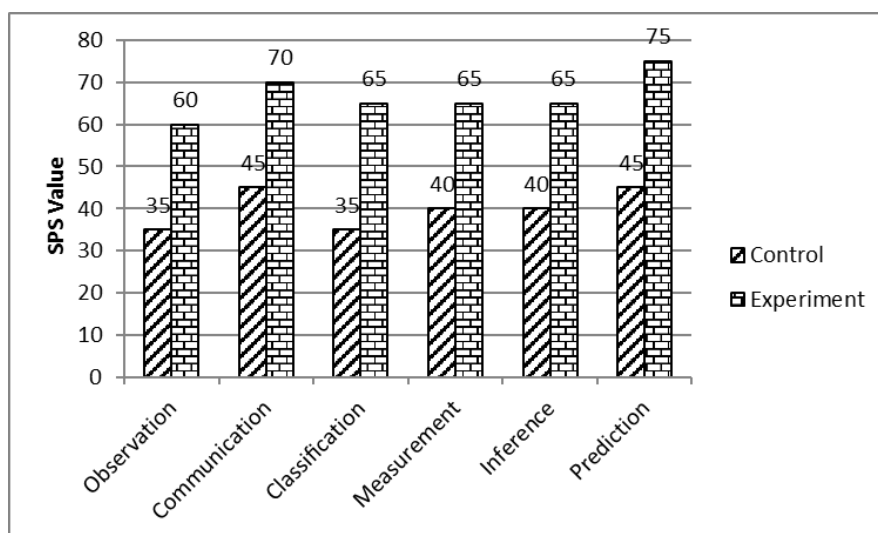


Figure 2. Comparison of N-gain mean values in each aspect of students' science process skills

From Figure 2, it can be seen that all aspects of science process skills of students in the experimental class have a percentage of normalized gain values $\langle N-g \rangle$ higher than the control class. So, it can be concluded that the improvement of science process skills of students in the experimental class with the use of PhET simulation software-based learning is higher than the control class with direct learning. Based on the above data it can be stated that PhET simulation software-based learning students can be more aroused in remembering and exploring concepts that have been studied before so that they can then relate to the concepts to be learned causing students to be motivated to actively participate in the learning process that helps them think about what knowledge they have before and then reflect it with new knowledge. In addition, students can directly observe changes in variables made for the concepts being studied. The simulation provided by PhET is very interactive which invites students to learn by exploring directly.

That way learning done by students is not only memorizing but students actively learn to find self-concepts with teacher guidance so that learning becomes more meaningful. The increase in science process skills that are significant in the experimental class compared to the control class is caused by the use of PhET software in applying this learning to make students more effective and efficient in conducting learning activities. With PhET software-based learning simulations students become more interested in conducting the learning process because extracting students' initial concepts can be done through simulation and other visual displays related to temperature and heat material so students can feel the concepts being taught are truly contextual and in direct contact with activities in daily life. In addition, the independence of students in learning to understand and understand their own concepts can be facilitated by the existence of PhET simulation-based learning software that can be accessed through the internet so students can repeat learning even practicum is done in a free virtual class anytime and anywhere without being bound by time and place [16].

The presence of the internet with all its advantages is seen as an alternative source of information for the future. The internet has a lot of potential that can support a better education process. The amount of information in it can be a literature for college people to broaden their horizons [17].

With the development of ICT, especially regarding the impact of message transformation, the learning process is undergoing change. The existence of internet media makes it easy for learning citizens to access various sources of information, including PhET. Through PhET, students learn to be able to transform their information to others so as to form a learning network or community known as virtual learning [18].

The process of exchanging information in cyberspace can also be applied to the teaching and learning process where various shortcomings of face-to-face meetings in ordinary classes can be built in PhET software. The idea that arises in the application of the PhET software simulation is to improve the quality of the learning process itself by implementing ICT that continues to grow rapidly.

PhET Simulation is learning software through computer devices connected to the internet, students try to obtain learning materials that suit their needs. PhET can be seen as a system developed in an effort to improve the quality of learning by trying to penetrate the limitations of space and time. Through PhET media, students' scientific process skills can be improved by following all the practicum experiments procedures virtually. Students are trained to solve problems provided independently through experiments, so students can build their knowledge through observing activities, asking questions, formulating hypotheses, designing and conducting experiments, processing experimental data and conducting discussions on the results of experiments that have been conducted. With this learning makes students able to work together in group discussions so that that requires students to provide input to other students so that students who have low academic achievement are more motivated in learning material that is less understood. By using a PhET simulation students can carry out activities to obtain data and facts as in a real laboratory, so that with these data and facts students can draw conclusions about the concepts of physics. PhET media is a virtual laboratory device that can display abstract concepts that cannot be displayed on real laboratory equipment. In mastering concepts, students can make predictions, explanations and understanding concepts better than students who practicum use real tools, so that through PhET simulations, science process skills can be improved through virtual practicum activities.

Computer simulation can be a solution if the equipment for real practicum is not available in the school even though it is very difficult if you want to replace the real practicum with a virtual practicum because the skills of students to use equipment in practicum are actually better. than students who only do virtual. Therefore, with the help of PhET software, which acts as a complement and students are facilitated in understanding the concept they learn through the findings they do independently.

4. Conclusion

PhET (Physics Education Technology) is a simulation media developed by the University of Colorado containing simulation of physics, biology and chemistry learning. PhET simulation media emphasizes the relationship between real-life phenomena and underlying knowledge. This research was conducted with the aim to determine the presence or absence of a significant effect of the use of PhET simulation media on the learning achievements of the basic energy material in the life system. The results show that learning using or assisting PhET software simulations is 37% better than conventional learning. It can be concluded that PhET software simulation can improve students' science process skills.

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